# Design and Analysis of Planar Microwave Antennas for Wireless Applications

**SHORT SYNOPSIS**

*Submitted in partial fulfillment of the requirement of the degree of*

**DOCTOR OF PHILOSOPHY**

*to*

*Manav Rachna International Institute of Research and Studies*
*(Deemed to be University)*

*by*

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## FACULTY OF ENGINEERING

### Certificate

I hereby declare that the short synopsis on "Design And Analysis of Planar Microwave Antennas For Wireless Applications" being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in ECE under faculty of Engineering of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2019.

It is a bonafide record of original work carried out under the supervision of Prof. (Dr.) Dipali Bansal and Dr. Yogendra Kumar Awasthi and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and the proof has been submitted.

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## ABSTRACT

Modern lifestyle cannot be imagined without wireless communication. It is a constantly evolving technology where the most important element is an *Antenna*. For effective & viable wireless communication, it is imperative to design an Antenna which is multi-band, has high Gain and wider Bandwidth to enhance channel capacity, which can be used for wireless 5G communication. It has been further studied that multiband application antenna structure with is compact, cost-effective, compatible and is easily installable needs design improvement. Improved radiation efficiency for better transmission & reception has to be achieved for an Antenna designed on a cost-effective substrate. For this purpose, a planar microwave antenna for multiband wireless application has to be designed. For bandwidth enhancement, a fractal dipole antenna will be designed and gain enhancement will be achieved by designing an array with the power divider method. For size reduction, notches will be introduced in the structure that will increase the electrical length. Various Antenna performance parameters like VSWR, Radiation, Beamwidth, Gain, SAR, etc. shall be recorded and analyzed with the help of Antenna simulation tool. Based on the simulated structure, hardware will be fabricated and performance parameters of a designed antenna shall be compared with the measured outcome. The outcome shall be measured through Vector Network Analyser ( VNA) and radiation will be tested in the Anechoic chamber.



**Keywords**: Planar Microwave Antenna, Wireless Applications, Anechoic Chamber, VSWR, Transmission loss, VNA

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## 1. INTRODUCTION:

A modern wireless communication system is evolved from technologies like 2G, 3G, LTE, WLAN (2.4-2.483,5.15-5.35and5.725-5.85 GHz) and Wi-Max (2.5-2.69, 3.3-3.8 and 5.25-5.85GHz). In order to fulfil the requirement of today needs, the necessity of antennas are also increased with modern specifications like compact shape, low cost, multiband operations, etc. Owing to the fact that antenna plays an important role in wireless communications. It converts electromagnetic signals into electromagnetic waves. The antenna is a transition part between a transmission line and space. It can be non-directional or directional. A wireless communication system is explained in Fig.1. It has two part antennas as transmitting antenna and receiving antenna and signal is passing through electromagnetic (EM) wave between transmitting and receiving antenna.

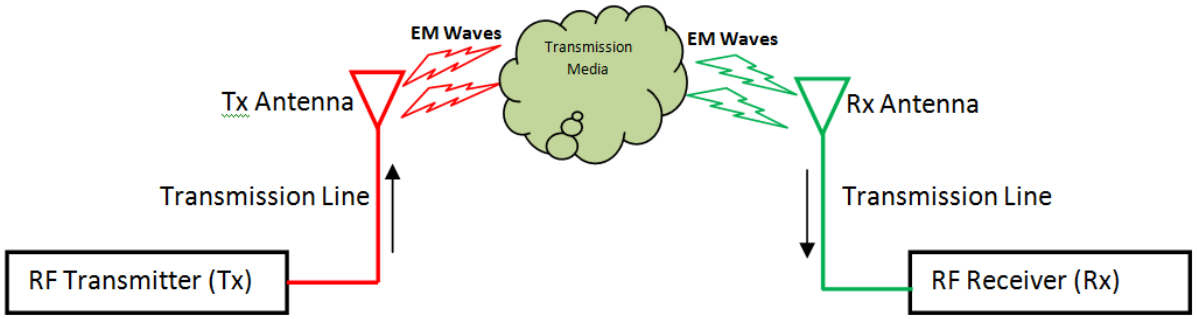


**Fig.1** Wireless communication system

**1.1 Wireless Technology:** In today's world, wireless technology is very advanced. It's growing rapidly too. In daily life, technology plays a very important role. According to (Naser, 2019) the square ring slot radiators provide good dual-polarization of radiation of MIMO antenna for 5G application. By using PIN diode and U-shaped structure antenna can achieve two-octave harmonic suppression for 5G (Nile and Zhai 2018). Antenna miniaturization technique can be achieved using fractals, by increasing electrical length and by the application of Koch structure at wider bandwidth for wireless application (Reddy, 2018). There is systematic development in the field of 5G. It is explained in Fig. 2.

Wireless has many applications in various fields:

1) Transmission of music, weather report, and broadcast of information.
2) For the remote location, through satellite exchange of information is done.

3) In moving a car, Global Positioning System (GPS) works and gives an exact location.
4) Laptops, Mobile phone, Smart TV are connected through Bluetooth (as it works for shorter distance too).
5) Online transaction of money is possible through internet only.
6) Tracking of animals is being done through Radio Frequency Identification (RFID).

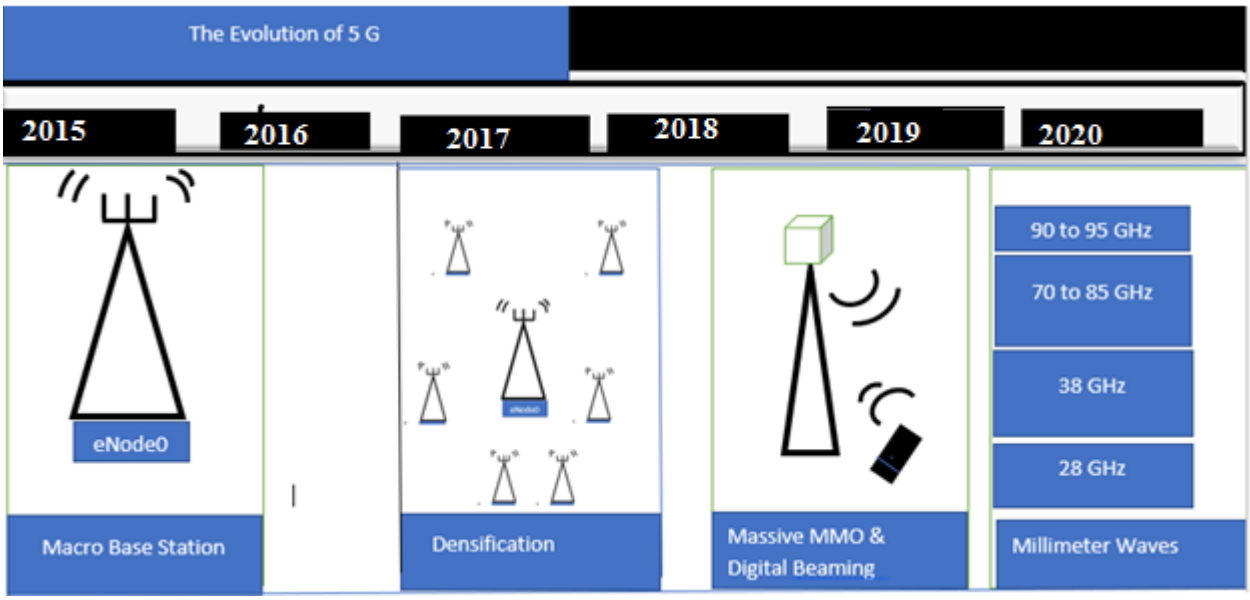


**Fig. 2** Evolution of 5G communication system

5G network allows communication irrespective of the fact that the subject is static or moving. For that planar microstrip array antenna has to be developed to give a solution for beamforming applications (Matos, 2018 and Goel, 2018). A differentially fed dual-polarized array antenna with wide bandwidth and high suppression gave wider bandwidth. Recently many antennas have been developed using dual-polarization (Tang, 2018).

Wireless technology is divided into various generations. It is the first-generation (1G) of wireless technology that is based on analog technology. Second-generation (2G) of wireless technology is where digital data is being used. Global System Mobile (GSM) was also launched as a part of second-generation technology based on time-division multiple access (TDMA) system. In third-generation (3G) which is based on code-division multiple access (CDMA) system. Fourth-generation (4G) includes more advanced technology with video conferencing, gaming service, here transfer of data with a very high rate is possible. Fifth-generation (5G) technologies include 2G, 3G, and 4G technology with its associated technology (such as GSM, UMTS, LTE, LTE

advanced pro, etc.). Here MIMO (multiple-input with multiple-output) is also possible, edge computing, small cell, beamforming, etc. is possible. It allows communication anywhere with the static or moving position or remote location as the data rate capacity is very high. There are various types of the antenna so while choosing an antenna many parameters has to be considered like-electrical, mechanical and structural aspects. For example Dipole, Directional, Patch, Microstrip, Sector, Yagi, Parabolic, Grid, Fractal, etc. while designing the antenna feeding is a very important parameter thus the antenna is fed using a subminiature version. An SMA connector is inserted via holes and is connected to the corresponding arms of the dipole (Rezaeieh, 2018). The 3D fractal antenna has the property of reducing the amount of material used in the amplitude modulation (AM) process (Yunjun, 2017). Bow-Tie is a special form of a fractal array, different methods have to be developed for a different parameter of the antenna design (Garcia, 2016; yang, 2015; Tan, 2016; Xu, 2015)

## 2. LITERATURE REVIEW:

A detailed literature analysis has been done on the current application of the antenna. A number of recent papers have been studied in the related topic to have an elaborate knowledge of recent and previous works. From the literature review only, one can find the gap between the two. This section includes the most recent techniques implemented by the researcher for antenna design that includes its software and hardware designing, few which are related to work are listed here.

In the modern world, there are rapid demands for high data transmission. In the present time in a rural area of data transmission speed is very low. To overcome this problem, a MIMO based antenna will be a good solution. It can increase data rate with limited power usage by using multiple antennas at both transmitters and receivers end as it transmits multiple independent data at the same frequency. Many researchers have suggested different applications of 5G technology. In MIMO antenna isolation will be a great task because of limited space in mobile phone and in MIMO antenna, a number of antennas will also be more. So, to achieve isolation different researchers have worked on different methods. Nadeem and Dong-You Choi (2019) have given an idea about different techniques of reduction of mutual coupling. In this theoretical review of different mutual coupling reduction technique in MIMO antenna system, it has been suggested that an increase in mutual coupling can reduce the performance of an antenna. Some of the methods are used to reduce the effect of mutual coupling between antennas like defected ground

structure, parasitic or slot element, complementary split-ring resonator, and decoupling network. Naser and Yasir (2019) have explained an eight-element dual-polarized MIMO slot antenna. Microstrip line feeding has been used for the reduction of mutual coupling in a closely spaced radiator. 3.4 to 3.8GHz frequency range has been achieved in this process. It provides wide bandwidth and good isolation. Nile and Zhai (2018) have explained about low profile frequency reconfigurable antenna work by adjusting PIN matching and it has been achieved at two bands of frequency. As it can be inferred here that in the above mentioned both the research works that they work on wider bandwidth. Varun, Ramas, and Matos (2018) have worked on beamforming by designing a planner antenna array. Here the author has worked on gain enhancement technique by using array. Guihong and Changhong (2014) also worked on the isolation method for a MIMO system. To achieve better isolation many authors have used the decoupling method but decoupling has an effect on radiation pattern and impedance. To solve this problem author worked on Partial ground among PIFA. This antenna can work on LTE and Wi-Max with good impedance matching. The coupling has few side effects on mobile phone also as a mobile phone is covered with metal rim, this metal rim generates unwanted coupling thus to reduce this problem Ying and Yan-Min (2015) have designed the broken metal rim with double slits. This slit worked as the antenna itself and it increases the bandwidth. In a separate paper, Meta structure has been introduced to reduce the coupling effect. Chenghui and Shiwen (2018) have used Meta-structure and decoupling surface in an antenna array structure. Here adjustable coupling structures have been introduced to improve impedance matching. The antenna structure has worked well for 2G/3G/LTE applications. Ying and Sihao (2018) have worked on two operating bands of frequency. Another method to suppress coupling is by using L-shaped and C-shaped filtering stubs and it is worth mentioning that by using filtering stubs isolation has been achieved between the lower and upper band. Decoupling is a big issue which decreases efficiency thus to overcome this Anping (2018) designed MIMO antenna for 5G application, here isolation is provided by radiating element itself and as a result, the overall size of antenna will be compact. Sharawi and Ihram (2016) have worked on compact 2 element slot-based MIMO antenna for 4G and 5G applications and for improvement in isolation separate ground plane has been used. Sun and Feng (2018) have worked on the orthogonal mode decoupling method to obtain better isolation and diversity performance. Yang and Qiang Xu (2016) have worked on eight-port dual-polarized antenna array, four are used for horizontal polarization and

four are for vertical polarization so eight antennas are embedded in a small space. Liu and Ming (2018) have worked on adding a vertical metallic patch to PIFA antenna. The vertical patch acts like perfect electric conductor (PEC) wall which can suppress fringing current on the ground plane.

On the other hand, several researchers worked on size reduction technique. Reddy and Prasad (2018) have worked on size reduction of fractal Antenna. Fractal gives good result in a multiband application. The rectangular slit has been added at just behind the feed line to improve impedance matching and gain has been improved significantly. Goel and Patnak (2018) worked on a broadband antenna for mobile application. Here the author has explained a microstrip line design for achieving wider frequency range. Tang, Liu, and Lian (2018) designed a folded four dipole antenna connected through a coplanar stripline. As a result of this experiment wide bandwidth has been achieved by them.

Rezaeieh and Abbosh (2018) have designed a bow-Tie antenna thus coupling has been achieved by using a folded structure of Bow-Tie. Other few mentionable results were by Perez and Goussetis (2017) who designed a power combiner for Ka-band application. Yang and Xin (2016) also designed a planar image reject bow-Tie antenna for superheterodyne application. Adding to that Tan and Withington (2016) have designed a compact microstrip antenna for Ku-band application and Lina, Li, Zhang (2014) have designed a broadband slot antenna for an asymmetric CPW.

Wu and chung (2015) have explained multi-broadband slotted Bow-Tie antenna and for this purpose, a coplanar waveguide (CPW) has been used as a fed line. Microstrip line feeding by using a pair of parallel strips. PIN diode has been used over the Bow-Tie arms and by using PIN diode effective length has been changed. The structure has been achieved as compact. Xu, Li, and Zhang (2015) have effortlessly explained about Bow-Tie antenna, in this loop strip has been added to increase the gain.

### 2.1 Highlight of Gap in Literature:

1) Multiband antenna is required for various 5G application.
2) A high gain antenna is required in 5G application for better diversity performance.
3) Larger bandwidth and compact design of the antenna can be explored for modern wireless application.

## 3. DESCRIPTION OF BROAD AREA :

### 3.1 **Wireless Communication:**

Transfer of data or information from one point to another without wire. There is no physical wire present between sender and receiver. There is electromagnetic radiation is used. Wireless technology uses infrared, Bluetooth, Wi-Fi, GPRS, etc.

Advantage of wireless communication:

1) Data transmission rate is fast.
2) Establishment and maintain a wireless connection is cheaper.
3) In a remote area also, communication is possible.
4) Working professionals can work anywhere using the internet without cable.

Design and analysis of planar microstrip antennas have been done for wireless applications. It can be done through RF (Radio Frequency) and IR (Infrared) waves. Same wireless frequency bands are explained in Table 1.

**Table 1:** Wireless frequency bands used for RF & THz Antenna Applications

| S. No. | Band | Frequency Bands | Applications |
|---|---|---|---|
| 1 | VHF | 3 to 30KHz | Audio Telephone ,Navigation |
| 2 | LF | 30 to 300KHz | Radio, Telephone |
| 3 | Medium Freq. | 300 to 3000KHz | AM Broadcast, Civil Defense |
| 4 | High Freq. | 3 to 30 MHz | Mobile Radio, Military Communication |
| 5 | Very High Freq. | 30 to 300MHz | TV, FM, Air Traffic Police |
| 6 | Ultra-High Freq. | 300 to 3000 MHz | UHF, Radio Space Telemetry |
| 7 | Super High Freq | 3 to 30 GHz | Relaying Broadcast, Radar, Satellite Comm. |
| 8 | Extremely High Freq. | 30 to 300GHz | Millimeter Waves, Wireless Radar |
| 9 | Terahertz- THz | 300 to 3000GHz | Biomedical Application |

### 3.2 **Planar Microwave Antenna:**

In the planar antenna, both active and parasitic elements are placed in one plane. Microstrip antennas and printed circuit board are used as a planar antenna. Shape and size of patch antenna can be different as per requirement. The planar microwave antenna is simply any printed antenna. It has the advantage of low profile, low cost, easy in geometry. While designing the high-performance antenna various parameter like size, weight, cost, easy installation, etc. are to be considered. To fulfill these requirements the planar microwave antenna is very useful. These antennae can be easily designed on a planar surface, where the antenna is easily mounted on the substrate. Planar microwave antenna schematic is explained in Fig. 3.

*Advantage of Planar Antenna:*

1) In the planar antenna, the manufacturing cost is low.
2) An antenna is small, easily access for wireless application.
3) It has a low profile.
4) Linear and circular polarization both can be used, depending on the design structure.

*Disadvantage of planar antenna:*

1) Mutual coupling is a major drawback in planar antennas
2) Usually, the radiation efficiency is low.
3) They have low gain.

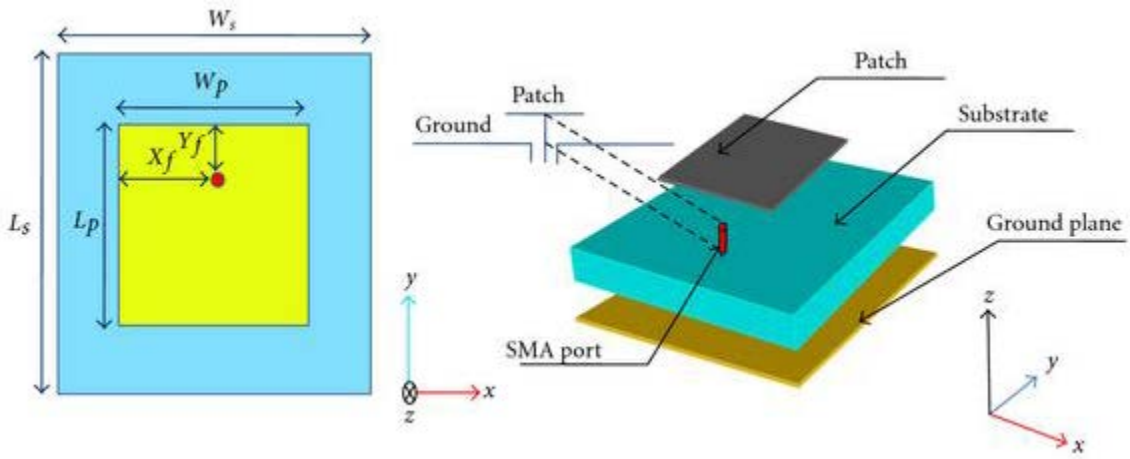


**Fig. 3** Schematic of planar microwave antenna

## 4. OBJECTIVE OF STUDY:

1) To design an antenna for multiband wireless application with enhanced performance.
2) To design an antenna array to improve gain for better transmission.
3) To design a compact antenna for wider bandwidth.
4) To calculate various parameters like radiation pattern, Bandwidth, VSWR, SAR, etc.
5) To compare the simulated result with a measured result.

## 5. METHODOLOGY TO BE ADOPTED:

Initially, the operating frequency of the antenna to be designed is selected and then appropriate substrate material is chosen. The antenna structure is designed with electromagnetic (EM)

modeling tool and then antenna with 50Ω feeding line is designed. The impedance matching between the ground and antenna is determined and the simulated result is checked if the result is achieved in the desired frequency range, then the structure is fabricated and the result is checked with Vector Network Analyzer (VNA). Antenna parameter like VSWR, radiation, gain, and bandwidth is calculated. At last comparison of simulation result with the fabricated result is to be done. In Fig. 4 whole methodology has explained with the help of the flowchart.

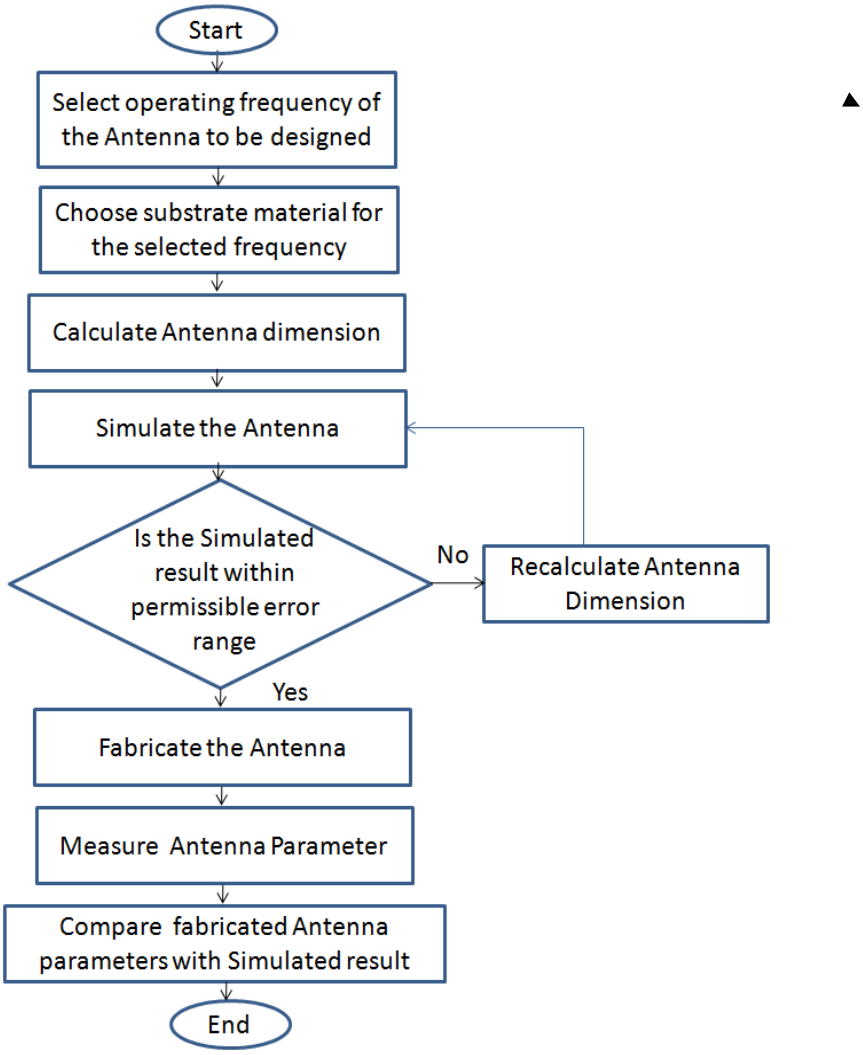


**Fig. 4** Flowchart of the proposed research methodology

## 6. EXPECTED OUTCOME OF RESULT:

1) An antenna structure with improved performance for multiband application shall be fabricated.
2) Gain and directivity are expected to improve through antenna array.
3) Compact antenna with wider bandwidth can be achieved.

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